Radiosurgery after embolization

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Kano and colleagues' meticulously detail and analyze their experience with stereotactic radiosurgery (SRS) in patients harboring arteriovenous malformations (AVMs) who had undergone prior embolization. Using a case-control matched approach, the authors determine that previously embolized AVMs have a lower rate of obliteration after SRS. This finding mirrors reports by other groups.

In 1960, Luessenhop and Spence9 published their early experience with embolization of cerebral AVMs using plastic or steel emboli. Since then, embolization has been used to cure small AVMs in some patients, occasionally to palliate symptoms by decreasing blood flow, and to decrease the nidus volume so as to make SRS or microsurgery feasible. Current embolic agents include polyvinyl alcohol (PVA) particles, silk suture, N-butyl cyanoacrylate (NBCA), and ethylene vinyl alcohol copolymer (Onyx, ev3, Inc.). From an embolization standpoint, there is no ideal agent among the 4 choices; each offers various tradeoffs in terms of safety and efficacy. Liquid agents tend to provide more effective, long-term embolization but are more dangerous to use. Also, they are radiopaque, making subsequent radiosurgical targeting more difficult. Silk and PVA particles are safer to use and are radiolucent, but vessels closed by these materials may recanalize over time.

Potential benefits of embolization before SRS include decreasing the volume of the AVM nidus, reducing the risk of hemorrhage by targeting the feeding artery or perinidal/intranidal aneurysm, and reducing symptoms of steal and venous hypertension. Based on the current study and our institutional experience at the University of Virginia, shrinking a large AVM to 8 cm³ or smaller allows for a more optimal dose to be delivered to the nidus. Reducing the target volume lessens the integral dose and associated risk of injury to surrounding brain tissue.

Such benefits must be weighed against the procedural risks and added expense of embolization. The disadvantages of embolization before SRS include direct procedural complications, difficulty with subsequent targeting due to CT and MR image distortion by embolic material, recanalization of untargeted areas, scatter and absorption of radiation by the dense embolic material, and inadvertent segmentation of the nidus into noncontiguous target volumes.10 Recent embolization series in which liquid agents were predominantly used demonstrated procedural morbidity and mortality ranging from 4.2% to 14% and 1% to 3.6%, respectively.

The trend at our institution has been away from preradiosurgical embolization except for patients with large AVMs or those with high-risk features such as aneurysms or fistulas. One underlying reason for this change is the difficulty with conformally targeting a less distinct and occasionally segmented nidus. We have also observed a decrease in the radiosurgical obliteration rate in previously embolized AVMs.12 However, one must be cognizant of the fact that patients with large AVMs are not ideal candidates for single-session SRS without prior embolization. A few centers including Pittsburgh have utilized volume-staged radiosurgery for large AVMs. However, based on the published results, it is less than certain that the AVM obliteration rate afforded by volume-staged SRS is superior to preradiosurgical embolization followed by single-session SRS. Moreover, the difference in complication rates between these 2 approaches needs to be better defined.

The results currently obtained using any single intervention (embolization, single or multisession radiosurgery, or microsurgery) for large-volume AVMs remain far from ideal. As such, combinations of approaches will continue to be used. In 1982, Charles Drake and colleagues4 wrote, “A long-term follow-up review is needed to determine the precise effects of partial or complete embolization on rebleeding, on seizures, and on progressive neurological deficits.” Unfortunately, 30 years later, this statement still rings true and particularly so in the context of partially embolized AVMs subsequently treated with radiosurgery. Neurosurgeons will need to systematically study outcomes so as to determine the best combination of approaches for such patients.

A more fitting analysis to explore the potential benefits of embolization prior to radiosurgery would be to perform a case-control matched analysis using preintervention AVM attributes. For example, keeping all other features equal, the natural history as well as the response to any single treatment of a 15-cm³ AVM with an associated aneurysm or varix is typically very different from that of an 8-cm³ AVM. Embolizing the 15-cm³ AVM and the associated aneurysm or varix down to an 8-cm³ volume does not mean that the vascular malformation is now equivalent to an AVM originally 8 cm³ in size and exhibiting no dangerous cerebrovascular features. However, in the current study, the case-control matched process used postembolization AVM features. Such an analysis results in a perhaps neces-
sary but overly simplistic comparison that neglects AVM differences that existed prior to any treatment and the risks accompanying such differences. These AVM features include differences in hemodynamics (blood velocity and volume), hemorrhage rates, angioarchitecture (nidal aneurysm, varix, and solitary, deep draining vein), and expression of vascular factors (vascular endothelial growth factor and basic fibroblast growth factor). After embolization, these features and their associated risks do not necessarily result in a lesion that has become equivalent to an AVM of similar volume that has not been previously treated.

It may be that partially embolized AVMs (typically those larger than 8 cm³ in original volume and/or those harboring vascular features prone to hemorrhage) are not more difficult to obliterate with radiosurgery because of prior embolization but simply because they are distinctly more challenging vascular malformations in the first place. The relationship between embolization and radiosurgery-induced obliteration could be predominantly correlative rather than causal. Nevertheless, Kano and colleagues are to be commended for their comprehensive analysis and sound conclusions. The current study offers the best insight so far into this controversial area of managing patients with AVMs.

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Disclosure

The authors report no conflict of interest.

References


Response

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We appreciate the concise and clear analysis performed by Drs. Sheehan and Yen relative to our report that describes our 20-year experience using a variety of arterial embolization techniques in patients who also underwent Gamma Knife surgery (GKS) for a wide spectrum of AVMs. This report supplements our prior analysis of almost 1000 patients who underwent GKS during a 20-year period.1–6 Drs. Sheehan and Yen are on target in their assessment. We would like to respond with a few additional points to amplify the results of our study.

Data from our center as well as others do not condemn or denigrate the usage of embolization as part of the management strategies for AVMs. Arteriovenous malformations are complex entities with variable morbidity risks that are related to location, volume, and associated angioarchitecture, including aneurysms and venous outflow obstructions. Embolization was first developed to be able to reduce flow through these complex lesions and theoretically thereby to improve the results of subsequent microsurgical removal or to reduce the risk of AVM hemorrhage. The preference for early embolization in patients harboring AVMs tends to be based on which gateway the patient enters for decision making of the available management options. Many patients over the years were referred to us after undergoing one or more attempts to treat the AVM by a wide variety of embolization techniques. Some patients sustained postembolization morbidity. Others had their AVM reduced in volume to one that, in fact, was more suitable for a radiobiologically effective dose to be delivered using GKS. Embolization techniques have steadily evolved...